RECENT GROWTH OF ENGINEERING COLLEGES.

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Presidential address, delivered at Topeka, November 30, 1906, before the thirty-ninth annual meeting of the Kansas Academy of Science.

IN looking over the field of recent engineering operations for indications of growth and unusual activity, far too much is discovered to warrant a simple notice even of all that is found.

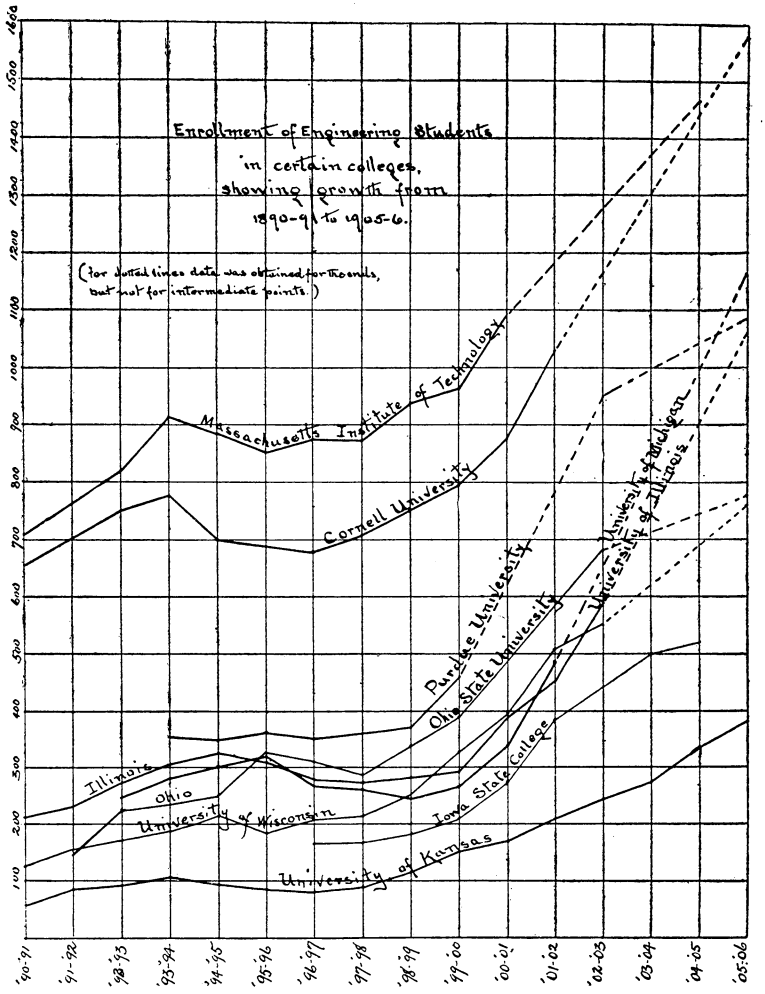
There are the great transcontinental lines, some new ones being built and others projected, and the double tracking and other improvement of old ones. There is the trend toward the substitution of electricity for steam locomotion, especially for service at terminals, and the development of interurban electric lines. The steam turbine has many achievements to its credit. The alternating current has been harnessed. Bridge and building construction is being revolutionized by the combination of concrete and steel, a matter made possible by a revolution in the methods of making Portland cement; a revolution so important for America that we are likely to wrest supremacy in the cement industry from Europe, as we not long ago forced her to yield her first place in steel. We are ushering in a cement age, as we then created a steel age. The gas-engine has come into prominence as a prime mover.

These and many others are great and interesting movements; yet the writer of this paper, being a teacher of engineering, and on this occasion speaking to a body of scientific people, most of whom are teaching science and its applications affecting the welfare of mankind, has chosen to turn to another great movement in which he has some part and about which he has some first-hand knowledge, and which, furthermore, lies beneath other movements as a basic or fundamental one.

To the teacher, indeed to every wide-awake and patriotic citizen, education is always an interesting and ever perennial topic, and to scientific people the recent rapid growth and development of the colleges of engineering in our land can but be of especial interest. This subject is a large and inexhaustible one, and only some phases of it can be discussed with any degree of adequacy within the limits of a brief address.

The report of the United States commissioner of education for the year 1899–1900 gives a total enrolment of students in universities, colleges, and schools of technology, exclusive of students in the pro-

fessional courses, of 98,923, of which number 11,874 were in engineering or architectural courses. The report for the year 1903–'04 gives, as corresponding figures, 118,816 for the total attendance and 21,087 for the engineers and architects. In these four years the increase in the total number of students attending college is 20.1 per cent., while for the technical students the increase amounts to 77.6 per cent., nearly four times as great a rate.



A study of the enrolment in a few of the prominent engineering colleges brings out certain general features common to all, as well as some differences. These institutions were chosen to represent different sections geographically, and which would therefore repre-

sent somewhat different surrounding conditions. They are the Massachusetts Institute of Technology, Cornell University, Purdue University, Ohio State University, University of Michigan, University of Wisconsin, University of Illinois, the Iowa State College, and the University of Kansas. The statistics given refer only to technical students, and the changes are shown graphically in the accompanying plate, for a part of which credit should be given to Prof. A. N. Talbot, of the University of Illinois, his diagram being extended and brought down to date. Beginning with the year 1890–'91, enrolments in all colleges show an increase up to 1894 or 1895 and then either a falling-off or practically a maintenance of numbers. This was due, no doubt, to the financial depression in the early '90's, which put a stop to so many public enterprises, lessening the demand for young engineers on the one hand and making their parents feel a monetary stringency on the other. But in the late '90's the schools began to feel the effects of the upward wave of prosperity, and their enrolments began to increase with a sharp rise about the year 1899–1900, the older Eastern schools taking the upward trend a year or two earlier. Since the beginning of the present century the rate of increase has been very remarkable, if not phenomenal, as is shown by the diagram, or by the subjoined table, covering the six years from 1899–1900 to and including 1905–'06.

GROWTH OF ENROLMENTS OF ENGINEERING STUDENTS IN CERTAIN COLLEGES.

Years 1899–1900 to 1905–'06.

COLLEGE.	Period beginning 1899–1900.	Per cent. of increase.	Average rate per year.	Enrolment last year.	Seniors in last year of period.
Mass. Inst. Technology	5 years.	52	10.4%	1,466	243
Cornell University	6 "	99	16.5	1,582	250
Purdue University	6 "	136	22.6	1,087	187
Ohio State University	6 "	99	16.5	787	73
University of Illinois	6 "	257	42.8	1,064	143
University of Wisconsin	6 "	136	22.6	768	113
University of Michigan	6 "	339	56.5	1,164	119
University of Kansas	6 "	153	25.5	379	33
Iowa State College	5 "	151	30.2	515	78

The percentages of increase in the case of the two Eastern colleges are relatively low, notwithstanding their rapid growth, because they already possessed large enrolments at the beginning of the period. They were also well equipped. The most remarkable expansion in numbers occurred with the group of institutions lying in the Mississippi valley. These found themselves placed under a

severe stress to provide for the instructional force and the equipment in buildings, laboratories and apparatus needed to properly care for the influx of students into engineering courses.

The growth of the Western schools has not been so spectacular, but has been none the less marked and real, and has led to the same pressing problems of administration, the same deficiencies in the number of instructors, the floor space required, and the equipment of drawing rooms and laboratories. In the institutions east of the Mississippi, the problems have been met and solved through legislative action, generously appropriating the necessary funds. The Western colleges, on the other hand, have felt the influence of the trend toward this form of scientific training, without the stimulus of generous legislative aid, for the lack of which they are now at this present time suffering. This is especially true in Kansas, where the state institutions have no distinctive engineering buildings and an inadequate equipment for the number of technical students already on the ground, to say nothing of the increased numbers that are sure to come in the immediate future.

The distribution of students between the various technical lines is interesting and is shown by the following table:

NUMBER OF STUDENTS IN VARIOUS TECHNICAL COURSES IN AMERICAN COLLEGES.

COURSE.	Year 1899–'00.†	1901–'02.*	1902–'03.†	1903–'04.†	Per cent. of increase in four years.
Civil engineering	3,140	3,694	5,278	6,118	90
Mechanical engineering	4,459	4,163	6,800	6,894	55
Electrical engineering	2,555	2,648	3,652	4,389	72
Mining engineering	1,261	1,453	2,244	2,324	84
Chemical engineering	.....	353	725	694	.....
Sanitary engineering	.....	.....	27	31	.....
Textile engineering	.....	.....	133	95	.....
Naval architecture	.....	81	.....	.....	.....
Architecture	459	362	558	542	18
Special engineering	.....	2,159	.....	.....	.....
Total	11,874	14,913	19,417	21,087	.....

* From proceedings of Society for the Promotion of Engineering Education.
† From reports of United States Commission of Education.

The above figures will show the recent trend as between the various lines of study chosen by students, but one can hardly say that this represents a permanent distribution, for the time covered is too short to warrant such a judgment. However, the introduction of courses in textile engineering in several Southern institutions is worthy of note as a new departure, as is also the increasing num-

ber of those choosing to enter the field of chemistry as applied to manufactures. This is a field that is promising as well as relatively new, and one that is not by any means fully occupied at the present. The increase shown by civil engineering seems somewhat abnormally large, although one looks naturally for that course to to show more growth in the last few years because of the widespread activity in public enterprises using the services of a civil engineer, and because the civil engineer graduate, from the less highly specialized nature of his college training, finds more possible openings before him and those of a greater variety and range than the graduate of other courses. In this the mining graduate is closely allied to the civil, though the recent increase in the numbers of those choosing mining is undoubtedly due to the revival in mining operations. The relatively low increase in the number of mechanical students is probably due to the popularity of electrical engineering, which, because of this popularity, due to its almost wizard-like accomplishments, has perhaps drawn unduly from its closely related course, that of mechanical engineering. Electrical engineering in reality is a branch of mechanical engineering, and it is a question not yet settled how far the two courses should be differentiated.

It is probably true that some of our courses in applied electricity in our colleges are too highly specialized along electrical lines and include too little of subjects found in mechanical courses to obtain the best training for all-round engineering work.

The falling out of students as they progress from year to year is also an interesting point. In the year 1901–'02, of the 14,913 students of technical courses in American colleges, only 1485 are classed as seniors. This is 9.9 per cent. For the college year 1905–'06, the Massachusetts Institute of Technology catalogued 16.5 per cent. of its total number of engineering and architectural students as seniors; for the last year, Cornell University, 15.8 per cent.; Ohio State University, 9.3 per cent.; Purdue University 17.3 per cent.; University of Michigan, 10.2 per cent.; University of Wisconsin, 14.7 per cent.; University of Illinois, 13.4 per cent.; Iowa State College, 15.1 per cent.; University of Kansas, 9 per cent. There are various reasons for this. The courses cover more ground and are made up largely of stiffer and harder work than is found in the ordinary college course, especially if the latter is one allowing of a wide range of electives; the engineering courses are more exacting then on a student's time and effort and many get weeded out early. Many students start with engineering under a notion that it is a good thing for them because it leads to good

salaries, only to find that they are not adapted to that kind of work. Then the knowledge and training received in the years below senior, in times of great prosperity like this, become of money value, and many students from choice or necessity become wage-earners, or even engineers with limitations. This point operates strongly in Kansas. Another thing that influences the above percentages is the very recent rapid growth in numbers, which, of course, swells the ranks of the freshmen chiefly. Yet it is interesting to note that of the entire number of 118,000 students of collegiate grade in 1903–'04, only about 15,500 were given degrees at the end of the year. This is very close to 13 per cent., a figure which therefore can fairly be taken as an average for the whole country. There will come a time when more normal conditions will govern and the ratio of seniors to total number somewhat larger than above given. A strong influence in this direction is the growing tendency on the part of railways and manufacturing concerns to require graduation from a good technical school of those seeking engineering employment.

In the true professional schools (for the engineering school is not a professional school in any strict sense), the percentage of graduates to total enrolment is considerably higher, being 23 per cent. for law, 21 per cent. for medicine, 30 per cent. for dentistry, and 29 per cent. for pharmacy. The reasons for this probably are that those entering these professional courses are either more mature or more definitely settled in their choice than those entering college or a technical school. Moreover, the standards of work maintained by some professional schools have not heretofore been as high as those of the colleges, although there seems to be a general advance in this respect.

There is another point of interest to be touched upon growing out of this statistical study. The United States census for 1900 gives the number of engineers and architects in active practice, as follows:

Civil engineers	20,153
Surveyors	6,034
Mechanical and electrical engineers	14,440
Mining engineers	2,904
Chemists, assayers, and metallurgists	8,887
Architects	10,604
Designers, draftsmen, and inventors	18,956
Total	81,978

But, as the surveyors are rarely men of college training, as many chemists and most architects are not technically trained, and as the

class last mentioned above includes relatively only a small number of technical graduates, it is probable that the numher of actual engineers at that date was not more than 50,000. Assuming that this number has increased to 53,000 at the present time, there is to be set against this body of practitioners the great body of 25,000 students, and we wonder what they are going to do, and ask whether this present trend of young men toward engineering is a healthful movement. We must look further to find an answer to the question.

It is said that the mean average growth of the number of wage-earners in America is about 3 per cent. per year, while the death rate is about 2 per cent. To provide for this growth and loss there would then be 5 per cent. of 53,000, or 2650 new engineers this year. If we assume 13 per cent. as the ratio of graduates to the total enrolment, as found above, this would furnish a body of 3250 with which to fill up the ranks. Hence, we might argue that the supply has reached or even overtopped the demand. Yet there is present another trend in modern affairs that sets this argument one side, and that is the growing recognition of the value of technical college training, followed by more or less of professional practice, as a basis for administrative business life. Engineers are constantly leaving the ranks of the profession for business openings, while young engineering graduates are accepting positions for which they are well fitted and in which they earn credit, but which can hardly be classed as strictly professional, although closely related thereto.

The truth is that any sound course in engineering is first of all educational, and professional only as a secondary matter. No school can make an engineer, for engineering as practiced is based on judgment, and this comes only as the result of experience. Some educators have tried to train young men into engineers, and some schools turn out graduates who believe that they possess technical wisdom, a notion that must needs be knocked out of them by hard experience before they can possess a sufficient amount of sense. The most that a school can do is to give a sound training, chiefly in mathematics and physical science and their applications, and an inculcation of principles, together with a small amount of professional knowledge, principally to help the young man to get a start without an exhibition of too much rawness. With it all, it must be recognized that the pupil is to be a man first and an engineer as a secondary matter. Indeed, he cannot succeed as an engineer without being true, honest, conscientious, simple-minded, open and frank, and without habits of hard work, of close and care-

ful observation, of weighing both sides of any point at issue, of searching for and clearly and strongly proclaiming the truth. Technical schools, in their laudable endeavor to fit men for practice, often for particular places, have sometimes lost sight of the real object of any right college work, and one of the encouraging things is another trend in engineering education that seeks to make more of the training of men as men without any real detraction from the scientific training.

That engineering courses are not professional is evidenced by the comparative ease with which young men, trained in one line in college, get into and succeed with another in practice. Civil engineers become miners, and *vice versa;* a miner becomes an expert in the cement industry; an electrical turns himself into a bridge engineer for a great railway. These and many other similar transformations have come within the writer's personal knowledge, as well as many instances of successful service in business or industrial life.

The young graduate, with his best acquisition a capacity for hard work, is somewhat the victim of circumstances and environment, and yet in the long run he will follow his bent and his natural likes. One becomes a scientific engineer, who loves his profession and his search for the truth in its problems, and who is content with a modest gathering of wealth. Another becomes a business engineer, attracted by the struggle of competition and the chances for accumulation. Both make use of their knowledge and scientific skill, but with slightly different aims. One seeks to obtain the best result for the least money expenditure; the other, so to plan that money returns may be the largest.

Our technical schools have largely planned their courses for the benefit of the first man, and it is a question that is now receiving consideration, whether they should not provide some specific training for the latter; and this is pertinent, because all engineers, of whatever type, necessarily must have to do with business affairs. It is certain that our engineering courses are strong in mathematics, the physical sciences, and their application and in drawing and design, at the expense of sufficient training in the use of English, a knowledge of the principles of economics, the elements of law, some study of business methods, the analyzing of the cost of production in manufacturing, some consideration of the principles of dealing with human nature and the handling of men, as well as some treatment of the matters of ethics and taste which materially affect a young man's outlook and his attitude toward life.

It is a serious matter to determine what to include and what to leave out in any four-year course of study, and in the present day this amount of time seems to be the maximum that one can expect to hold the great majority of students. Some things must be left out, and some left to be touched incidentally only through the personal influence of the teacher and his contact with the pupil. In the main, the engineering schools are quite close together as to their requirements, though courses of study are under constant discussion and are open to revision. In this matter there is no more potent agency at earnest work than the Society for the Promotion of Engineering Education, whose influence has been strongly felt in the thirteen years of its life.

There is yet another movement among the engineering colleges of very great import, not only indirectly to students, but directly to the public at large. This is a growing spirit of investigation, the attempt to take up and solve many scientific questions relating to the materials of construction, their use, or to methods of design. Twenty years ago there was very little of this kind of work done, outside of one or two institutions, and teaching was almost wholly led by practice; but to-day, the results of the thinking and investigation of the college men are leading the practitioners. The modern use of the alternating current grew out of the work of college men. The standardizing of the requirements for paving brick came from work done in a college laboratory. The Cornell hydraulic laboratory, with its unequaled opportunities, is open for the study of unsolved problems. The University of Illinois has published results of investigations concerning reenforced concrete, high-speed tool steels, the collapsing of tubes, the holding power of railway spikes, and the drainage of earth roads. The University of Wisconsin has made a valuable contribution to our knowledge of reenforced concrete. The Massachusetts Institute of Technology conducts postgraduate research work in sanitary engineering of great value. The Iowa State College is applying energy to investigations of economic value to the state. Indeed, there is hardly an institution of any great importance that is not doing some practical research work.

While the University of Kansas has done something along this line—investigations of building stone, paving brick, gas, oil, etc., and has in progress some study of stone for the improvement of roads, a systematic water survey of the state, in connection with the State Board of Health and the United States government, and other studies of public importance—the applied-science men of its

faculty have been too much occupied with the teaching function and too poorly supplied with space, equipment and money to warrant much development in this way. It is to be hoped that in the immediate future the state colleges of Kansas may be properly equipped to do systematic research work on economic engineering lines.

This movement is an exceedingly healthful one, for it adds strength and vitality to the teaching side of college life on the one hand, and furnishes scientific results of a high order on the other. College men are better adapted to study, investigate and draw unprejudiced conclusions concerning questions of this kind than any other class. They can have—indeed, are likely to have—a better equipment in the way of literature, laboratories, apparatus and other facilities as a basis for work; they are in close touch with workers in all scientific lines; only they must have both time for the work and available funds.

In conclusion, the writer believes that the trend of American youth toward colleges of applied science is a healthful movement, fully justified by the conditions of life as they now exist and will exist for many years to come; that applied-science college work furnishes a pretty severe training, leading to habits of industry, honesty in forming opinions, respect for truth, and a knowledge of how to attack and master real problems; that this training results in a class of men who bring things to pass; that it possesses a definite cultural value, though limited in its scope.

He further believes that applied-science colleges are but beginning their career of usefulness, not only as places for the higher education of youth, but also as centers of applied science, where investigations of utilitarian questions go on side by side with those of pure science—not simply side by side, rather with hand in hand; for no new truth of science is discovered but that, sooner or later, it is found to have its practical application somehow or somewhere.

He still further believes that every college of engineering, to rightfully fulfil its mission to both pupil and public, should include both functions, that of teaching and that of doing research work.

And finally, he believes that the spirit underlying the work of these colleges is such that they will not be content with present attainments and present standards of efficiency. Recognizing defects and limitations, they must and will struggle and work for better and higher results.

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